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RESERVATION OF UNFERMENTED GRAPE-MUST

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PRESERVATION OF UNFERMENTED GRAPE-MUST.

By Frederic T. Bioletti and A. M. dal Piaz.

The use of unfermented grape-juice or "must" as a beverage, both in health and sickness, has been common in vine-growing countries from time immemorial. It has, however, until lately been restricted to the immediate vicinity of the vineyards and the season of ripe grapes. This is owing to the great facility with which fruit juices of all kinds spoil within a few days after being expressed from the fruit, unless preserved artificially. The great progress made within the last few decades in methods, both legitimate and illegitimate, of food preservation, has made it possible to keep grape-juice for an indefinite period, and to make use of it as a beverage at all seasons and in all places. Accordingly the manufacture of grape-must has attained notable proportions in some European countries, and in some parts of the United States. Its use, however, has up to the present day been almost exclusively medicinal, although it is one of the most wholesome and agreeable beverages known, in health as well as disease. The cause of this restricted use is twofold. In the first place, in order to simplify and cheapen the processes of manufacture, injurious preservative agents have been made use of by the unscrupulous, and, in the second place, the lack of the necessary special knowledge and technical skill has resulted in many failures of attempts to preserve the must in a legitimate manner, so that the price has been necessarily too high for the regular consumer.

It is to remedy this lack of knowledge on the part of the manufacturer, to warn the consumer against the injurious effects of antiseptics, and to call attention to the merits of this delicious beverage that this Bulletin is written. More stress is laid on general principles than on actual methods, as the methods will vary considerabl according to the scale on which the manufacture is conducted an according to the facilities and appliances at the disposal of the individual manufacturer. The business can be conducted profitably wit either small or large quantities, but must necessarily be commence on a modest scale by the inexperienced. The directions given her should enable almost any grape-grower to commence operation and gradually, as he acquires confidence and skill, to engage mo largely in what should be an important industry in California.

Composition of Grape-Must.—A consideration of the following table, showing the constituents of the normal juice of ripe grapes, will make clear its value as a nourishing beverage in health, and also its therapeutic efficacy in certain cases of disease:

	Parts in 1,000.
Grape sugar (dextrose and levulose)	180 to 280
Free organic acids (tartaric, malic, tannic)	1 to 10
Salts of organic acids (cream of tartar, potassium malate, calcium tartrate, calcium malate	4 to 8
Ash (containing potassium, sodium, calcium, magnesium, ferric oxide, phosphoric and sulfuric acids)	3 to 5
Nitrogenous matter (proteids, amido-compounds)	3 to 10

This table shows that some of the principal constituents of wine, such as alcohol, glycerine, etc., are totally lacking in pure grape-juice; and it is to be noted that it contains no unwholesome substance of whatever kind.

Grape-juice should and can be delivered to the consumer so as to contain no other substances than those shown above. If chemical analysis shows any other ingredients, a fraud has been practiced; and as all the additions usually made are in the nature of antiseptics or preservatives, they are all more or less injurious. All the antiseptics used are easily detected by more or less simple chemical tests, and if an effective pure-food law were in operation it would be easy for the consumer and the honest producer to protect themselves by occasional chemical analyses of the various brands of grape-must on the market. In the larger European countries, where such laws do exist, the use of injurious adulterants is rendered dangerous, if not impossible.

An analysis of a pure grape-must made by a government chemist in Austria, and one of must put up by Swett & Son, at Martinez, made by Mr. G. E. Colby at this station, gave the following results:

Analyses of Grape-Must.

	Austria. Per Cent.	California. Per Cent.
Solid contents by spindle (Balling)	21.62	20.60
Alcohol	none	none
Total acid (as tartaric)	.78	.53
Volatile acid	.01	.03
Grape sugar	19.62	19.15
Cream of tartar	.61	.59
Free tartaric acid	.03	.07
Ash	.37	.19
Phosphoric acid	.02	.04

No cane sugar, starch sugar or antiseptics, were found in the California or the Austrian musts. Artificial (Anilin) coloring matter, salicylic, benzoic and boracic acids, formalin and fluorides were tested for in the California must but none were present.

made at this station, of some of the beverages offered to the consume in California under such titles as "Unfermented Wine," and "Pur Grape Juice," recommended for invalids and for communion purposes

SAMPLE 1.

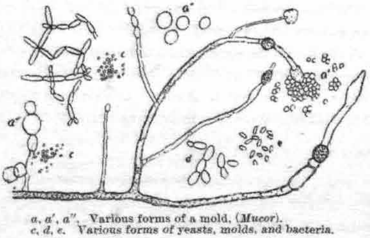
	Per Cent.
Solid contents by spindle	22.00
Total acids (as tartaric)	.59
Sulfurous acid (antiseptic)	.06

SAMPLE 2.

	Per Cent.
Solid contents by spindle	20.80
Alcohol, by volume	2.00
Salicylic acid (antiseptic)	3.90

The first sample was sold as a "curative for throat and lun troubles." The amount of sulfurous acid it contained was sufficient t *cause* throat and lung as well as digestive troubles in a healthy person The second sample was sold as "pure unfermented grape-juice," bu besides containing a large amount of the injurious antiseptic salicyli acid (more than twenty times as much as was necessary to preserve it) it contained two per cent. of alcohol. Even healthy persons, mucl more invalids, would contract severe indigestion from the use of sucl a product, which is a fraud upon the public.

Causes of spoiling.—In order to make clear the nature of th problem which must be solved in order to preserve grape-juice indefi nitely, a short accoun of the causes of spoilin will be useful. Whe grapes, or any fruits are gathered, the sur faces in contact wit the air have the spore of various fungi, yeasts and bacteria adherin to them. All thes spores are microscopic but an idea of thei appearance, when sufficiently enlarged by the microscope to be visible may be obtained by reference to Fig. 1, which shows various form of these organisms developed on the skin of a muscat grape.



a, a', a''. Various forms of a mold. (*Mucor*).
c, d, e. Various forms of yeasts, molds, and bacteria.
Fig. 1.—MICRO-ORGANISMS ON GRAPES.

When the grapes are crushed and the juice expressed, the latte will be contaminated by these spores, washed off the skin. In the ai they are dry, and therefore inert; but very soon after they ar surrounded by the must, which is a very favorable medium for thei growth, they assume an active form and commence to multiply. I the must is warm, this change to an active state occurs very soon and

the consequent increase in numbers is proportionately rapid. If, on the contrary, the grapes and therefore the must be cool, the increase is much slower; but, eventually, if left alone the organisms increase until the must ferments. This fermentation consists principally in the changing of the grape sugar into alcohol and carbonic acid, and is the essential part of the process which changes grape-juice into wine.

The main object, then, of the producer who wishes to place "pure unfermented grape-juice" upon the market, is to permanently prevent this fermentation. Besides this, the grape-juice must be quite clear, in order to present an attractive appearance to the consumer.

To attain the first object there are two general groups of methods, which may be called respectively *chemical* and *physical*. All the chemical methods consist in the addition of germ poisons or antiseptics, which either kill the microscopic organisms of fermentation or permanently prevent their growth and increase. Of these substances the principal used are, besides salicylic and sulfurous acid already mentioned, boracic acid, saccharin, and, of late, formalin. Many patent preservatives are found on the market, but they nearly all contain one or more of these substances as their active principle. They are all injurious to digestion and in other ways; and it may be said in general that any substance which prevents fermentation will also interfere with digestion, and is therefore to be avoided.

The *Physical* methods work in one of two ways: they remove the germs by some mechanical means, such as a filter, or a centrifugal apparatus; or they destroy them by heat, cold, electricity, etc. The methods which depend upon the removal of the germs are inapplicable, as this cannot be done thoroughly except with very small quantities of liquid, and the minute organisms with which we have to deal will soon increase sufficiently to spoil the liquid, if a single one escapes the filter. One yeast-cell, for instance, at ordinary temperatures will increase to tens of millions in three or four days; and if the temperature is warm the increase will be still more rapid. We are, then, reduced to those physical methods which destroy the germs; and of these the only one which has been found useful in this connection is the use of high temperatures. This method depends on the fact that when a liquid is heated up to a sufficiently high temperature all organisms present are killed. This temperature is called the "death point," and differs for each particular variety of organisms. The death point will also differ according to the composition of the liquid in which the organism is immersed. Yeast, for instance, is killed at a lower temperature in must than in water, on account of the acidity of the former. Time, also, is a factor in determining the death point. An organism may not be killed if heated to a certain degree quickly

and as quickly cooled; while if it is kept at that same degree for some time it will be killed. Some tests made at this station with a pure* yeast isolated from a California wine illustrate these facts. The yeast was placed in must which had previously been completely freed from all germs, and was heated to various temperatures for various lengths of time, with results as follows: The initial temperature of the must was 20° C. (68°F.) and the yeast was killed by heating it gradually up to 60° C. (140° F.) in fifteen minutes; that is to say, the time taken to bring the temperature from 20° C. (68°F.) to 60° C. (140° F.) was fifteen minutes, and at the end of this time the must containing the yeast was allowed to cool in a room at 20° (68° F.). This same yeast was not killed when heated in twenty-five minutes from 20° C. (68° F.) to 50° C. (122° F.), nor even when kept at the latter temperature for five minutes longer. But when kept at this temperature for ten minutes longer, all the yeast cells were killed. Another test with the same yeast showed that if heated from 20° C. (68° F.) to 45° C. (113° F.) in twenty minutes, and then kept at the latter temperature for twenty minutes, few or none of the yeast cells were killed, though in thirty minutes most of them were rendered incapable of growth. However, even in the last case some were left alive and ultimately spoiled the must. We learn from these tests that heating to 45° C. (113° F.), even for a somewhat prolonged time, cannot be depended on to sterilize grape-must, and that even 50° C. (122° F.) requires too much time to be practical. A heating to 60° C. (140° F.), however, would probably be quite safe, provided that only this particular variety of yeast were present in the must. In practice, however, we have an unknown number of kinds of micro-organisms present, and some of them may be able to withstand a somewhat higher temperature than this.

It must be kept in mind also that fungi, including yeasts, exist in two states, the vegetative or growing state, and the spore or resting state. The latter is more resistant than the former; and it has been found that yeast spores, for instance, to be killed must be heated about 5° C. (9° F.) higher than the same yeast in the growing state. The above tests were made with yeast containing no spores; but, as in practice, spores may be and undoubtedly usually are present, a temperature 5° C. (9° F.) higher than indicated would be necessary. Practical experiments made at this station indicate that must can be safely sterilized at a temperature of 75° C. (167°F.) or 80° C. (176°F.) if all the precautions indicated below are observed. At this temperature the flavor of the grape-juice is hardly changed, though at between 90° C (194° F.) and 100° C. (212° F.) it is slightly affected.

* Pure in this case means a yeast consisting of only one variety of micro-organism.

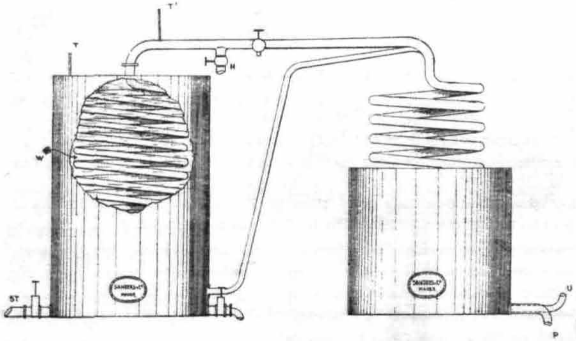
Another property of fungi and their spores, which is of importance in this connection, is their great resistance to heat when dry. Yeast can be heated in a dry state to a temperature above that of boiling water without being killed; the spores of some fungi (*e.g.*, common mold) are even more resistant. The bearing of this upon the preservation of must is that during the final sterilization, which takes place in glass bottles or similar vessels, portions of the inner surface of the cork and of the bottle above the liquid are comparatively dry; and if any spores should be adhering to these parts there is danger that they will not be killed, and that afterwards, when they come in contact with the must, they will grow and cause fermentation or mold. For this reason both the bottles and the cork must be thoroughly sterilized *before* being used. This can be accomplished for the bottles by boiling them for at least half an hour after thorough washing, and then allowing them to drain in a place where they are exposed to no draughts or dust. This boiling should be done as short a time as possible before filling the bottles, and they should be handled carefully, taking care not to touch their mouths, for with the greatest care the hands cannot be kept free from mold spores. To sterilize the corks this method is not always sufficient, as spores that may be in cracks are liable to escape. For sterilizing the corks, some closed receptacle should be used which will safely withstand considerable pressure. The corks when placed in this receptacle can best be sterilized by steam under pressure, which is allowed to flow in until the pressure, as shown by a gauge, is at least ten pounds. This pressure indicates a temperature of about 115° C. (239° F.), and should continue for at least twenty minutes.

Apparatus required.—The apparatus necessary for preserving grape-must on any but the very smallest scale consists of: 1, a continuous pasteurizer; 2, a pressure filter; 3, a pressure sterilizer for corks (this may be dispensed with); 4, a bottle pasteurizer; 5, a boiler for pressure steam. Certain other utensils are, of course, necessary, but they are such as are found in almost every wine-cellar.

The manner of operating.—The method of proceeding is as follows: Sound, clean grapes, preferably those having high natural acidity, are picked carefully, while cool, into clean boxes. They should not be too ripe or the must will be too sweet and difficult to clear. They should be crushed as soon as possible after picking, and the juice run into perfectly clean puncheons or other receptacles which have been previously steamed. If the must is cold—15° C. (59° F.) or under—it may be safely left to settle for twenty-four hours or more. This settling is an advantage, as it rids the juice of most of the floating solid matter, and facilitates the subsequent filtering. During this

settling the must should be closely watched, in order to anticipate even a commencement of fermentation. After this settling, when the must has become almost clear, it is run through a continuous pasteurizer, of one form of which Fig. 2 gives an idea.

It is heated in this to 80° C. (175° F.) and should come out cool, not warmer than 25° C. (77° F.) and should pass into fresh settling receptacles. For this purpose puncheons or other casks may be used, if they have been thoroughly sterilized by steam, though the best receptacles would doubtless be casks or vats of metal lined with enamel, such as are now made. The greatest care must be taken to avoid contamination of the must as it flows from the pasteurizer. It



ST, Steam pipe. *H*, Outlet for hot pasteurized must. *U*, Inlet for unpasteurized must.
W, Water bath. *P*, Outlet for cooled pasteurized must. *T*, *T'*, Thermometers.

FIG. 2.—CONTINUOUS PASTEURIZER.

should pass directly, by means of a block-tin pipe, from the pasteurizer into the receiving casks. The end of this pipe should be thoroughly sterilized by plunging into boiling water, and should never be allowed to touch the hands or any exposed surface. When a receiving cask is full it should be closed immediately with a wooden bung, sterilized preferably in the way already described for corks. If all these operations have been conducted with the requisite care, and the casks kept in a cool cellar, the must will remain without fermenting for many days or even weeks. During this time it deposits more or less sediment which has been formed in heating. It is then ready for filtering.

Filtration.—This filtration is best accomplished by means of a filter so constructed that the must passes upward through the filtering medium, under pressure. Such a filter, made by the International Filter Co. of Chicago, is shown in Fig. 3.

This filter consists essentially of two shallow bowls clamped together mouth to mouth with the filtering medium between them. The unfiltered must enters the lower bowl through the pipe on the right of the figure, passes through the filtering medium into the upper bowl and makes its exit when clear through the faucet a little to the left of the middle of the figure. The small faucet at the bottom of the lower bowl is for the purpose of cleaning the filter. Occasionally, when filtration becomes slow, this faucet is opened for a few moments. This allows the sediment accumulated at the bottom to escape and at the same time the entering must takes a rotary course in the lower bowl, thus cleaning off the surface of the filtering medium; so that when the cleaning faucet is closed filtration proceeds as before. On a large scale, a filter press, such as is used in large wineries and in beet sugar factories, might conveniently be used.

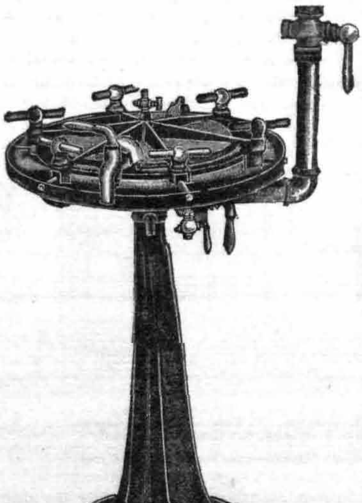


FIG. 3.—FILTER FOR CLARIFYING MUST.

It is impossible to prevent a certain amount of contamination by fungous spores during filtration; but it should be minimized as much as possible by the greatest cleanliness, and attention to sterilizing everything with which the must comes in contact. In this regard it should be kept constantly in mind that in an ordinary room or cellar, where there is little dust, there is comparatively little danger of contamination from the air, the main danger being from the solid surfaces with which the must comes in contact. The must may be bottled directly as it flows from the filter, or it may pass into a sterilized temporary receptacle, from which it is bottled. It should, however be placed in its final receptacles (bottles, etc.) the same day on which it is filtered, corked immediately, and sterilized as soon as possible, preferably within 24 hours.

matter various substances are extracted from the skins, the principal being tannin. This makes the composition of the red must more like that of red wine, though of course it still contains no alcohol. A grape-juice of this character might appropriately be called "Unfermented Wine," and would doubtless be useful in medicine, as it would possess certain tonic properties not found in the white must. The regular consumer, however, would in all probability generally prefer the white must.

Grape-must, containing as it does generally from twenty to twenty-four per cent. of sugar, is too sweet for many palates and constitutions, but it may be diluted with water by the consumer to any desired extent; and a mixture of equal parts of grape-must and carbonated or mineral water makes a beverage much appreciated by many people. In Europe a certain amount of sparkling grape-juice is put up, *i.e.* grape-juice which has been carbonated, or charged with carbonic acid gas. This, though an addition to the natural juice of the grape, cannot be looked upon in any sense as a fraud or adulteration, and makes the beverage more palatable to many; besides if properly done it has no injurious effects on the health of the consumer.

In conclusion the following brief summary of the main precautions to be observed in the manufacture of unfermented grape-must may be useful:

1. Only clean and perfectly sound grapes should be used.

2. The grapes should be picked and handled when cool.

3. The greatest cleanliness is necessary in every stage of the process.

4. All utensils and apparatus used should be cleaned and sterilized immediately before using, and as short a time as possible after using.

5. The last sterilization should be at a temperature at least 5°C. (9°F.) lower than the temperature used in the first sterilization.

6. Reliable thermometers should be used, and the temperature watched very carefully.